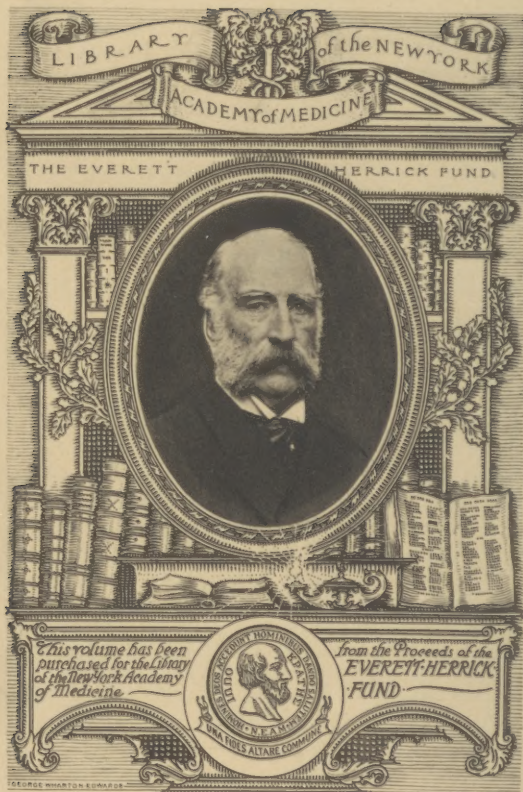


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Ten
Lessons in Chemistry
For Nurses

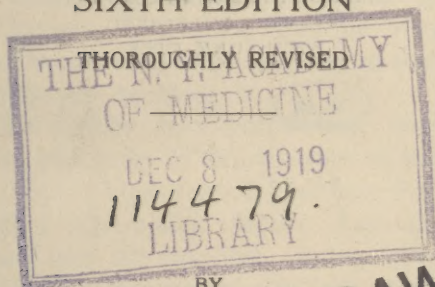
BY
MINNIE GOODNOW, R. N.

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Ten Lessons in Chemistry For Nurses

SIXTH EDITION

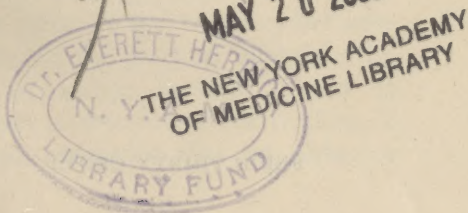


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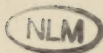
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PRICE THIRTY CENTS

Preface to Sixth Edition

This small book has the honor to be the first Chemistry for nurses that was published in America. It appeared first as a series of articles in *The Trained Nurse and Hospital Review*. Up to the time of that printing Chemistry had not been a part of the nurse's curriculum, for the very good reason that there existed no text suitable for teaching it.

The author had found that only about one nurse in ten, whether or not she was a high school graduate, had studied Chemistry before her entrance into the hospital. It was also found that, because of this lack, pupil nurses failed to properly comprehend their other studies, notably *Materia Medica*, *Physiology*, and *Dietetics*.

After study of the situation and consideration of the practical difficulties involved in adding another subject to an already overburdened curriculum, it had been concluded that no elaborate

nor extended study of Chemistry was necessary for the nurse, but that a text consisting of a clear, brief statement of fundamentals would be sufficient. It had been felt that any attempt to write a complete Chemistry for nurses would defeat its own object, because such a volume would be bound to contain extraneous matter, not directly applicable to nursing. It seemed desirable not to encumber any course of study with more than the essentials; the subject-matter was therefore reduced to ten short lessons.

In these ten lessons were set forth the foundation principles of Chemistry and chemical changes, especially such as pertain to the nurse's work and to her other studies. Effort was made to simplify and elucidate these principles and to show their practical application.

The work has been very kindly received by hospital training schools and many have found it adapted to their needs. It has recently been carefully revised.

Ten Lessons in Chemistry for Nurses

Supplies for Experiments.

THE teacher of chemistry should bear in mind that experiments made before the class are far more impressive than any recital of text can possibly be. It is therefore strongly advised that all experiments given in the following pages be actually made by teacher or pupils. The material for them is of the simplest character, and will not cost more than a couple of dollars. It will be found already on hand in most hospitals. There is practically no apparatus needed.

The following is the list of things needed:

- 2 oz. sulphuric acid,
- 2 oz. hydrochloric acid,
- 2 oz. powdered sulphur,
- $\frac{1}{2}$ dram iron filings,
- 1 oz. chloride of lime,
- $\frac{1}{2}$ oz. tincture of iron,

$\frac{1}{2}$ dram solution silver nitrate,

$\frac{1}{2}$ oz. sugar of lead,

$\frac{1}{2}$ oz. powdered alum,

1 oz. washing powder,

A few crystals of copper sulphate,

A few small pieces of zinc,

A Bunsen burner or alcohol lamp, a few test tubes and a glass rod should be provided.

LESSON I.

Composition of Matter.

All matter, everything which we can see, handle, taste, smell, or deal with in any way by our senses, is divided into two classes, organic and inorganic.

Organic substances are those which have a certain definite structure built up by the mystic force which we call life. They are usually products of plant or animal life. Wood, sugar, muscle, milk, etc., are examples.

Inorganic substances are those structureless materials which we call metals, minerals, earth, soil, etc. They are usually formed without the aid of animal or vegetable life.* Salt, borax, iron, etc., are examples.

Organic matter we learn, is composed of cells. A *cell* is a minute portion of jelly-like substance with a thin wall about it, and a nucleus within. This, the simplest living structure we know, is quite complicated in comparison with a bit of mineral matter. Even a microbe or germ, small as it is, has a

* Some substances, like coal and ichthyol, are the remains of vegetable or animal life, now become mineral.

definite structure with parts unlike each other; whereas a piece of iron or gold is the same throughout. We resolve a cell into its simplest elements, and we find it composed of different kinds of material. We resolve a piece of iron into its simplest elements, and we find the same sort of material repeated over and over again.

In imagination we divide organic matter smaller and smaller in order to learn its final composition. By various processes we arrive at the conclusion that it is composed of substances similar to inorganic matter. We try to go further, but fail. We have not now at our command any microscope or other instrument delicate enough to show us the smallest parts into which organic or inorganic substances may be divided. We can conceive that they might be capable of almost infinite division, yet we finally arrive at the ultimate bit, which cannot be further divided without destroying its identity. These smallest particles we call *molecules*.

A molecule, then, is defined as the smallest portion of matter which can exist alone.

We may ask if molecules are not capable of division. The following experiment will suggest the answer.

1. Dissolve a pinch of sugar in a small quantity of water. Add more water gradually, tasting often. It will be found that a very small quantity of sugar can be detected in quite a large quantity of water. This shows us that though the sugar be divided into particles so small that we cannot see them with the most powerful microscope it is still sugar, the original substance.

2. Place a small portion of cane sugar on a china dish. Pour over it ten or fifteen drops of sulphuric acid. The sugar presently turns yellow, then amber, then brown, and after a considerable time becomes quite black. This black substance resembles neither sugar nor sulphuric acid, but looks like fine charcoal mixed with some liquid. We find by further study that it is exactly this.

3. Put some sugar on a tin plate and hold over a flame. The sugar browns, smokes, bubbles and finally becomes a charred black mass.

We see by these two last experiments

that the sugar is no longer sugar, *but* has become some other substance. We infer, therefore, that a change has taken place which has broken the sugar up into its constituent parts. These smallest parts we call *atoms*.

An atom is the smallest portion of matter which can exist in combination.

This considering of matter as divided into molecules and atoms is known as the *Atomic Theory*. It is entirely theoretical, but the facts of which we have any knowledge fit the theory. Scientists have adopted it, therefore, as a foundation for the work of chemistry.

What chemistry is. Chemists have, by long series of experiment, found that few substances are simple, but that very many are composed of two or more other substances. The study of these experiments and of the conclusions drawn from them is called chemistry.

Chemistry is the science of matter, its properties and changes.

Chemical and Physical Changes.

If we heat water to the boiling point, it goes off into vapor or steam. If the steam be cooled, it returns to its original

form. If we cause it to freeze, we have a solid mass, which we call ice. A slightly higher temperature returns it again to water. Such changes in the form of a substance are called *physical changes*.

The first experiment with the sugar—the making of a solution—is another example of a physical change, for if we evaporate the water we may obtain the sugar in its original form.

The second and third experiments are entirely different matters for in those cases we had formed an entirely new substance. Such a change occurring in the composition of a substance is called a *chemical change*.

Experiments to Illustrate Chemical Changes.

1. Mix powdered sulphur and fine iron filings. Use a magnet, and it will be found easy to separate the two substances. Look at the mixture through a strong magnifying glass, and you may readily see particles of each substance. Put some of the mixture into a test tube and heat to redness. It becomes a mass in which neither iron nor sulphur can

be distinguished, and which is neither one nor the other. By the first process we have a mechanical *mixture*; by the second, a chemical *compound*.

2. Put a little ammonia water into a small glass vessel. Add a small quantity of tincture of iron. A dark red, rather heavy precipitate will be formed, which may be washed on fine gauze and examined by the class.

3. Put some normal salt solution into a glass. Add several drops of a solution of silver nitrate. Note the bluish-white precipitate formed.

4. Put a spoonful of fresh chloride of lime into a tall glass vessel (a Mason jar will do), and pour over it a little 50 per cent sulphuric acid. Cover for a few minutes. A greenish-yellow gas will appear of a penetrating and disagreeable odor.

5. Blow gently through a glass tube into a bottle of lime water. The clear solution will presently become milky, and soon there will appear a fine white precipitate which settles to the bottom of the bottle.

The above experiments illustrate chemical changes. In the first, two sol-

ids—iron and sulphur—united to form a third solid. In the second and third, two liquids produced a third liquid and a solid. In the fourth, a liquid and a solid produced a gas. In the fifth, a liquid and a gas (from the breath) produced a solid. These suggest the innumerable combinations possible.

LESSON II.

Chemical Laws.

Elements. There are in the world about two hundred and fifty thousand different substances. These, in varying forms and combinations, compose all the things of which we have any knowledge.

When we trace these numerous substances back to their origin, and break them up into their component parts, we find that there are but seventy-eight different kinds of matter. There may be fewer than this, but we have not yet been able to ascertain.

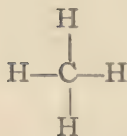
These seventy-eight are absolutely simple substances, which cannot be divided into anything simpler. They are called *elements*.

An element is a chemically simple

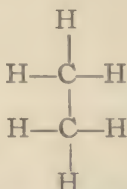
substance, from which nothing else can be extracted.

Substances which contain more than one element are called *compounds*.

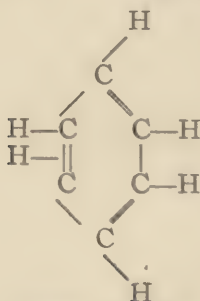
Their infinite variety is produced by the various possible combinations of the elements; just as many thousands of words may be formed by the combination of selections from the twenty-six letters of the alphabet. The following illustrate some of the common forms of compounds.



Methane (C H_4)

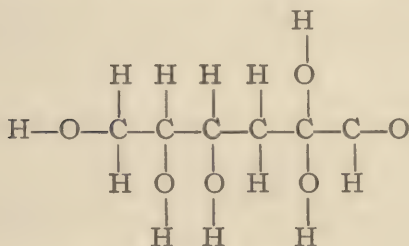


Ethane ($\text{C}_2 \text{H}_6$)

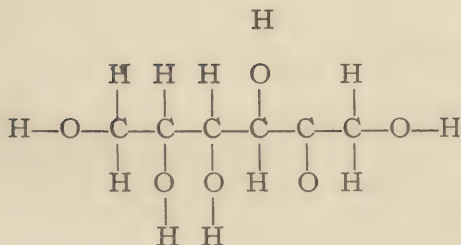


Benzene ($\text{C}_6 \text{H}_6$)

In some cases, compounds have exactly the same composition, but a different arrangement of atoms produces a different substance. For example, glucose (grape sugar) and fructose (fruit sugar) have the same formula, $C_6 H_{12} O_6$, but a slight difference in arrangement of atoms.



Glucose ($C_6 H_{12} O_6$)



Fructose ($C_6 H_{12} O_6$)

A chemical compound is held together by a force which we call chemical affinity.

In the iron and sulphur experiment cited above, we had at first a simple mechanical mixture, which upon heating became a chemical compound. The process was as follows: Each molecule of iron contains a fixed number of atoms; each molecule of sulphur likewise. The application of heat broke up the molecules of each substance into their atoms. An exchange of atoms took place, and we had formed a new set of molecules, each containing atoms of iron and atoms of sulphur, held together by chemical affinity. These new molecules were iron sulphide, a substance quite unlike either of its original elements.

The same thing happens whenever a chemical change takes place. Most of such changes are far more complicated than the example given.

We find, incidentally, that *either heat or moisture, or both, are necessary for the production of a chemical change.*

Fill a test tube half-way to its top with cold water. Add to it slowly

about thirty drops of sulphuric acid. Hold the tube closely in the hand and note the heat which is evolved in the rapid reaction between the acid and the water.

In chemical reactions, heat is always evolved. It may be much or little, depending upon the rapidity and violence of the reaction.

The putting together of elements to form compounds is called *synthesis*. Note later the so-called "synthetic compounds."

The breaking up of compounds into the elements which compose them is called *analysis*.*

There are, it has been said, seventy-eight elements. These have very different properties, both physical and chemical. For the sake of simplicity, we designate each element by an ab-

* A chemical analysis of the human body results in some interesting disclosures. We are told that the normal, healthy man who weighs one hundred and fifty pounds is the exact equivalent, chemically speaking, of one thousand hen's eggs. He consists of over thirty-eight quarts of water, which makes up over half his weight; sixty lumps of sugar, twenty spoonfuls of salt, iron enough for seven spikes, two pounds of lime, thirty-five hundred cubic feet of gas, oxygen, hydrogen and nitrogen; over twenty pounds of carbon, or enough for about ten thousand lead pencils; phosphorus enough for about eight hundred thousand matches, and starch, sulphur, chloride of potash and hydrochloric acid in lesser quantities.

breviation, called a symbol, in some cases a single letter. A part of these abbreviations are from the Latin name of the element. The following is a list of some of the more common elements with their symbols:

(It will be noted that some of the elements are gases and a few are liquids, but that most of them are solids.)

Al	—Aluminum.
Sb	—Antimony (stibium).
As	—Arsenic.
Bi	—Bismuth
B	—Boron.
Br	—Bromine.
Ca	—Calcium.
C	—Carbon.
Cl	—Chlorine.
Cu	—Copper (cuprum).
Au	—Gold (aurum).
H	—Hydrogen.
I	—Iodine.
Fe	—Iron (ferrum).
Pb	—Lead (plumbum).
Li	—Lithium.
Mg	—Magnesium.
Mn	—Manganese.
Hg	—Mercury (hydrargyrum).
Ni	—Nickel.
N	—Nitrogen.
O	—Oxygen.
P	—Phosphorus.
Pt	—Platinum.
K	—Potassium (kalium).
Ag	—Silver (argentum).

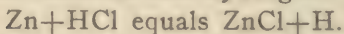
Na—Sodium (natrium).
Sr—Strontium.
S—Sulphur.
Sn—Tin (stannum).
Zn—Zinc.

Compounds are indicated by writing together the symbols of the elements which compose them. For example, common salt—sodium chloride—is a compound of sodium and chlorine; its formula is NaCl . This formula also tells us that the molecule of salt contains two atoms, one of each element. When a molecule contains more than one atom of a kind we write the symbol with a small figure below and to the right. For example, water is H_2O , each molecule containing three atoms, two of hydrogen and one of oxygen. Ammonia is NH_3 , four atoms, one of nitrogen and three of hydrogen.

Equations. An expression of the change taking place when a chemical reaction occurs is called a *chemical equation*. It is put into the usual form of equation and indicates an addition or exchange. For example:

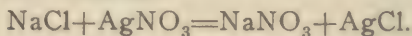
Iron and sulphur make iron sulphide.
 $\text{Fe} + \text{S}$ equals FeS .

Zinc and hydrochloric acid make zinc chloride and hydrogen.



In experiment No. 3, Lesson I, the reaction is as follows:

Sodium chloride (common salt) and silver nitrate make sodium nitrate and silver chloride.



Nomenclature. The various compounds occurring with different proportions of the same elements are distinguished by names which suggest their composition. For example, CO is carbon monoxide, CO₂ carbon dioxide. H₂O (water) is hydrogen monoxide, H₂O₂ hydrogen peroxide. HgCl (calomel) is mercurous chloride. HgCl₂ (corrosive sublimate) is mercuric chloride or bichloride of mercury.

Laws Governing Chemical Reactions. Elements do not combine with one another in any definite or uncertain way, but always in exact proportion by weight, according to a fixed law. This is called the *Law of Constant Proportions*.

Elements, may, however, combine with each other in more than one pro-

portion. These varying quantities are found to be exact multiples of the smallest amount that can enter into combination. The rule which governs this is called the *Law of Multiple Proportions*.

(This law should be kept in mind particularly in studying the organic compounds.)

Law of the Conservation of Matter. The total weight of matter resulting from a combination or decomposition is always equal to the sum of the weights of all substances taking part in the reaction.

This means that there is just so much matter in the universe, and that no changes of any sort can affect the *amount* of each *element*. There is now in the world no more or less iron than there was ten thousand years ago. There is not a grain more or less of silver on our planet than there was in the days of Noah; neither is there more or less oxygen or hydrogen. The *number* of compounds may be more or less, and the amount of each *compound* may be very different from what it was a year or a century

ago, but the entire quantity of each element remains eternally the same. We cannot destroy any element, nor can we create the smallest portion of one. Compounds we may make or destroy, as we possess the requisite means or knowledge, but the final elements are beyond man's control.

To a casual observer this law seems not always to hold good; for example, in the burning of a candle matter seems actually to disappear. Exact experiments, however, prove that the gases which pass into the air in the process of combustion are, with the ash which is left, equal to the weight of the original substance plus the amount of oxygen consumed from the air in the process. (See Chemistry of Flame, Lesson VI.)

LESSON III.

The Elements.

Many of the elements are familiar to us. Others need description. *Hydrogen* is a gas without color, taste, or odor. It is the lightest of all known elements. Hydrogen is rarely found uncombined; it has a great affinity for oxygen, the two combining readily to form water. Water being so abundant, it will be seen that the amount of hydrogen in the world is very large.

Hydrogen is found chiefly in organic substances, *i.e.*, plants and animals, and in some mineral substances. It burns readily, with a very hot flame, combining with the oxygen of the air to form water vapor. (The oxy-hydrogen blowpipe is a device which produces the hottest flame known to science.)

Oxygen also is a gas without color, taste, or odor. It is a very active element, *i.e.*, will combine with almost everything. Oxygen forms about one-fifth of the air and about one-third of the water of the globe; occurs largely in all animal and vegetable matter, and

in nearly all rocks and minerals. It is, in short, the most abundant element, and makes up over one-half of the earth's surface. Its tendency to combine with everything is in a large measure responsible for the changes which take place so constantly in organic compounds, decay, rust combustion, and even the disintegration of rocks.

(Water, H_2O , is an interesting compound from the fact that it is a fluid formed by the union of two gases; two intangible, invisible substances uniting to form a tangible, liquid mass.)

Nitrogen is a colorless, tasteless, and odorless gas, which forms four-fifths of the air and is in organic and inorganic substances in considerable quantity. It is very inactive, and under ordinary circumstances will hardly combine with anything.

Growing plants and animals need a great deal of nitrogen, but are unable to obtain it from the air. Their supply comes from the nitrogenous compounds in the soil in other plants and animals. Blood, muscle, and nerve substance contain nitrogen, as do the

grains and some vegetables. Nitrogen does not burn, nor does it support combustion.

Air is a mechanical mixture, not a chemical compound. It contains about four parts nitrogen, one part of oxygen, and a small amount of watery vapor, carbon dioxide, and other substances.

Carbon is the chief constituent of all organic substances. Three forms in which we best know it are coal, diamond and graphite (the lead of pencils). Charcoal, bone-black, lamp-black, coke, peat, petroleum, asphalt, etc., are more or less pure carbon. Marble, limestone and chalk are compounds of carbon. Sugar, starch, vegetable fibers, fats, oils, alcohol, ether and innumerable other substances are carbon compounds.

Charcoal, which is almost pure carbon, absorbs large quantities of gas into its pores. This makes it a valuable disinfectant and deodorant in the sick room.

Carbon dioxide, also called carbonic acid gas (CO_2), is one of the most important carbon compounds. It is

formed during combustion, and is thrown off in considerable quantity by animals in the process of breathing. (See Lesson VI.)

Sulphur is a yellow, crystalline element more or less familiar to us. It occurs in the earth uncombined, especially in volcanic regions. Small quantities are found in plants and animals, as in mustard, yolk or egg, bile, hair, etc. Sulphur is used in bleaching and as a germicide.

Phosphorus is a common element, but not an abundant one. It occurs in many rocks (in combination), in the soil, in seeds and grains, in the bones and brains of animals, in urine, blood, etc. It does not occur in nature uncombined. Pure phosphorus is a violent poison; it is the chief ingredient in matches.

Calcium, commonly called lime, occurs as marble, limestone, chalk, in plants, in animals and in water. It is an important constituent of bone, teeth, shells, etc.

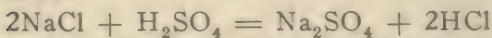
Sodium is a silver-white metal, never occurring alone. It cannot be kept in water or air on account of its great

affinity for oxygen; it is only preserved in the pure state by being placed under naphtha or some liquid which contains no oxygen. If a small piece of sodium can be obtained, exhibit it and show its action when dropped upon water. It immediately breaks into a bluish-white flame. This is due to its affinity for oxygen, which it takes from the water and combines with rapidly. Since chemical reactions always produce heat, the extremely rapid process makes an intense heat which causes the burst of flame.

The commonest and most important compound of sodium is the chloride, common salt. It forms about 3 per cent of sea water, and some of the salt lakes contain nearly 30 per cent. It occurs as rock salt in many parts of the world (Poland and Spain); in our own country, as in New York and Michigan, it is obtained by evaporating the brine from salt wells, slow evaporating producing large crystals; rapid, small ones. It is found in the blood of animals and in their bones. Normal salt solution contains the same amount of salt as human blood

does, and is often used to supply a loss in case of hemorrhage or in collapse. It is a direct heart stimulant, acting not as a spur, but as material upon which to work.

Sodium chloride is used largely in manufacturing other products. Sodium sulphate, Glauber's salts, a hydragogue cathartic, is made from salt and sulphuric acid. The reaction is as follows:



Sod. chlor. Sulphuric ac. Sod. sulph. Hydrochloric ac.

Sodium carbonate (washing soda or sal soda) and sodium bi-carbonate (baking soda) are also made directly from salt. Sodium hydrate, or caustic soda, is another common soda compound. It is a strong alkali, used in soap-making.

LESSON IV.

Chemical Compounds.

Acids are compounds of hydrogen and non-metallic elements. Some of them, however, contain a metal and many have oxygen in addition. They have a sour taste and turn blue litmus

red. (Litmus is a vegetable extract obtained from a species of lichen.)

The three most common acids are sulphuric, nitric and hydrochloric. Their formulae are as follows:

Nitric acid..... H N O_3

Sulphuric acid..... H_2SO_4

Hydrochloric acid..... HCl

(Carbolic and carbonic acids are not true acids, though called by that name.)

Nomenclature. There may be two acids containing the same elements, but in different proportions. In this case the name of the one having the least oxygen ends in *ous*, the other in *ic*. For example, H_2SO_4 is sulphuric acid, H_2SO_3 sulphurous. HNO_3 is nitric acid, HNO_2 nitrous. Their compounds are named in a similar way: Calomel is mercurous chloride, corrosive sublimate is mercuric chloride.

Bases are compounds of oxygen hydrogen and a metal. They have an acrid taste and turn red litmus blue. A base which is readily soluble in water is called an *alkali*.

An *alkali* reaction is the turning of red litmus blue.

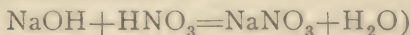
An *acid reaction* is the turning of blue litmus red.

It will be seen from this that acids and bases, or acids and alkalies, have opposite characteristics.

A substance is said to have a *neutral reaction* when it is neither acid nor alkaline, *i.e.*, does not affect either red or blue litmus. This may be illustrated as follows:

Put a small amount of dilute caustic soda (a strong alkali) into a dish. Add to it hydrochloric acid drop by drop, stirring with a glass rod. Test frequently with litmus paper, both red and blue. If the acid is put in carefully we can obtain a solution which will change the color of neither kind of litmus and is therefore neutral.

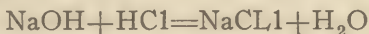
(The reaction is



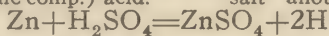
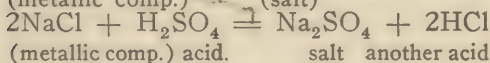
Alkaloids are plant bases. They are complex compounds containing nitrogen and carbon, and having qualities very like bases or alkalies. They are the "active principles" of the plants from which they are obtained. A plant may produce more than one alkaloid; for example, morphine, code-

ine and heroin are all alkaloids of opium. Alkaloids are usually violent poisons, and when used medicinally are given in very small doses. (See Lessons X.)

Salts are compounds produced by completely or partly replacing the hydrogen of an acid with a metal. They may be made by combining a base and an acid. The following equations illustrate how the reactions occur:



Sodium hydrate acid common salt water
(metallic comp.) (salt)



metal acid salt

(The English words *salt* and *salts* have three different meanings, which should be clearly distinguished. Common *salt* is familiar. A chemical *salt* is a compound formed as stated above. "*Salts*" is the name given to various drugs having a purgative action, usually salts of sodium.)

Nomenclature. The names given to the various salts correspond to those of the acids from which they are derived. Acids whose names end in *ic*

form salts ending in *ate*. Those with names ending in *ous* form salts ending in *ite*. Thus KNO_3 is potassium nitrate, KNO_2 potassium nitrite.

Double salts are those in which two metals replace the hydrogen of an acid. Rochelle salts is an example of this, its chemical name being sodium and potassium tartrate.

Crystallization. Most salts occur in the form of crystals. Why certain substances take this form is a matter not well understood. It happens whether the salt is a natural or an artificial product.

As a rule, each substance has one particular shape of crystal which it always assumes. They are large or small, according to circumstances.

The following experiments illustrate the formation of crystals:

Make a hot saturated solution of sal soda. Cool it and note the crystals which are formed. Do the same with a hot solution of alum. Note the different shapes of crystal which each solution gives.

Mix powdered alum and powdered copper sulphate, and make a hot satur-

ated solution of the mixture. When this is allowed to cool two kinds of crystals, blue and white, of two different shapes, are formed. This experiment shows us how natural crystals of pure substances are formed; advantage is also taken of this when we wish to obtain a pure salt from a mixed solution.

(These experiments take considerable time, and 24 to 48 hours should be allowed for them.)

Nearly all crystals are formed in exactly this way, by the evaporation of a solution either by natural or artificial means. Often in the process water is added to the elements forming the crystalline compound, not making a chemical combination, but simply a physical addition. This is called "water of crystallization," and is easily removed without disturbing the chemical compound.

Place a few large crystals of copper sulphate on a piece of tin and hold it over a flame. The water of crystallization evaporates and a pale blue, almost white, powder remains. This is still copper sulphate, and the color

may be restored by adding a little water. The same "efflorescence" takes place slowly if the substance is left exposed to the air.

The opposite occurs in other crystals. Instead of giving up water to the air they take it in from the air, and literally dissolve themselves. If a small amount of potassium acetate in crystals is placed on a bit of paper and left open it will in a comparatively short time begin to soften and will presently become a liquid. Substances which do this are called *hygroscopic* or *deliquescent*, and should always be kept in air-tight bottles carefully corked.

Stable and Unstable Compounds.

Some chemical compounds are stable, *i.e.* are broken up with difficulty; some are unstable, *i. e.*, are easily broken up. The explanation is as follows: The atoms of some elements prefer to combine with but one atom of another element; some prefer two, some three, and so on. (Atoms are thus denominated univalent, bivalent, trivalent,

etc.) When each atom of a compound has what it prefers or can best attach itself to, it is said to be "satisfied," and the compound formed is *stable*, being held tightly together. So if any atom has more or fewer atoms than it wishes, they are all held less closely, and the compound is *unstable*.

LESSON V.

Organic Compounds.

In time past there was a sharp distinction made between *organic* and *inorganic* compounds. A change has occurred in this matter in recent years, since we have been able to prepare artificially many compounds which were formerly obtained only from plants or animals. We therefore use the terms *carbon compounds* and *compounds not containing carbon* as being more exact expressions.

Inorganic substances, as a rule, contain few atoms, while organic compounds usually contain many. It is for this reason that organic compounds are likely to be unstable, and that some of them have similar formulae. (See page 13 for examples of similar compounds.)

Synthetic Compounds. Certain dye-stuffs, such as madder, cochineal and indigo, previously gotten from vegetable and animal sources, are now manufactured synthetically from inorganic substances, chiefly coal tar. Saccharin, a coal-tar product, is four hundred times as sweet as sugar and

is used in place of it in some diseased conditions, notably diabetes. Vanillin, also made from coal tar, has the taste and odor of the extract obtained from the tonka or vanilla bean, and is used in its place. A number of medicinal drugs which were formerly gotten only from plants are now made up from mineral substances. Sodium salicylate, used extensively in the treatment of rheumatism, is an example of this; the so-called "true" sodium salicylate is made from winter-green or from willow bark, and is expensive, whereas the ordinary product is made up from coal tar and is quite cheap. New compounds, medicinal and otherwise, are constantly being discovered; these are analyzed, *i.e.*, separated into their constituent parts, and later are made up artificially from substances of mineral origin.

This is simply doing in another way what nature is constantly doing for us in her way. In nature, plants grow and develop by means of the inorganic matters which they extract from the soil. Animals do the same thing to a limited extent, but usually obtain

their food materials ready prepared for them by plants or other animals which got them from plants. Thus, our muscles are built up and nourished by materials derived from meat, grains, vegetables, or fruits, but which came originally from the earth or from the air. There can be, therefore, no sharp line of distinction between organic and inorganic compounds, for in a multitude of instances they are composed of exactly the same elements.

When we reduce plants to their original elements, we find them composed chiefly of carbon, oxygen, hydrogen, nitrogen, potassium and phosphorus, the first three being the most abundant. These elements occur as starch, sugar, woody fiber, water, and all of the thousands of substances which we call vegetable matter. (The various chemical changes which take place in the growth of plants will be briefly discussed in the next lesson.)

Man and other animals throw off in various ways matter for which they have no further use. Urine, feces, carbon-dioxide from the lungs, scales of dried epithelium from the skin, dead

hairs, nails, etc., everything which we call waste, goes back again to Mother Earth. Wind, water, cold, heat, and the various natural forces act upon these substances which have been discarded, break them up into their elements or modify them in one way or another, thus making them ready again for the plants to feed upon. Bacteria frequently assist these processes.

When men or animals die, the same thing occurs on a different scale. The whole organism is broken up and acted upon by external forces or forms of matter which make new compounds ready for the use of future beings. Plants in dying undergo a similar process, which does not differ materially whether it takes a long or a short time. A tree may be burned up in a single hour, or it may be years in decaying; but in either case it is resolved into its elements, these elements being set free to help in the formation of other plants, animals, or rocks, as the case may be.

Thus the *law of the conservation of matter* continues its operation, and the whole process is a round of transform-

ation, change, decay and upbuilding.

Carbon Compounds. Practically all organic substances, whether animal or vegetable, are composed of carbon, hydrogen, and oxygen, with small quantities of nitrogen, sulphur, phosphorus, etc. The number of compounds formed by the combination of these elements is quite remarkable. In some cases it may even occur that the chemical formulae of two substances is exactly the same, but a different arrangement of the atoms may produce a different substance. The following table of formulae of various organic sub-compounds, chosen at random, will serve to illustrate the infinite variety of the carbon compounds:

Cane or milk sugar.....	$C_{12}H_{22}O_{11}$
Fruit sugar	$C_6H_{12}O_9$
Starch.....	$C_6H_{10}O_5$
Alcohol.....	C_2H_6O
Wood alcohol.....	CH_4O
Oxalic acid.....	$C_2H_2O_4 + 2H_2O$
Acetic acid.....	$C_2H_4O_2$
Ether	$(C_2H_5)_2O$
Carbolic acid.....	C_6H_5OH
Camphor.....	$C_{10}H_{16}O$
Caoutchouc.....	C_5H_8

Formaldehyde	H_2CO
Tannin.....	$\text{C}_{14}\text{H}_{10}\text{O}_9$
Cocaine.....	$\text{C}_{17}\text{H}_{21}\text{NO}_4$
Quinine.....	$\text{C}_{20}\text{H}_{24}\text{N}_2\text{O}_2 + 3\text{H}_3\text{O}$
Morphine.....	$\text{C}_{17}\text{H}_{19}\text{NO}_3 + \text{H}_2\text{O}$
Strychnine.....	$\text{C}_{21}\text{H}_{22}\text{N}_2\text{O}_2$
Chloride of lime.....	CaOCl_2
Chloroform.....	CHCl_3
Glycerin.....	$\text{C}_3\text{H}_5(\text{OH})_3$
Soda Carbonate.....	NaCO_3

It will be seen from this how very slight changes in composition may produce very marked changes in external qualities. There is, moreover, a very great difference between organic and inorganic substances of the same composition. The inorganic compounds are more firmly held together and yield less readily to changes in their surroundings. Organic compounds, on the other hand, are apt to be unstable, *i.e.*, are readily broken up and, by a slightly different arrangement of atoms, reformed into other compounds. This enables us to understand the many and intricate changes which take place during the physiologic processes of digestion and nutrition.

LESSON VI.

Combustion. Breathing.

Chemistry of Flame. Hold a tumbler mouth down for a moment over a candle flame, and note the film of watery vapor which appears on it. Hold a piece of cold metal in the flame and note the soot (pure carbon) which is deposited on it.

The process of combustion (burning) is as follows: The tallow or wax of a candle is composed of carbon, hydrogen and oxygen. The burning wick melts the solid material and transforms it into a liquid. This liquid is drawn up by the wick, vaporized and decomposed by the heat. The process of combustion takes oxygen from the air, combines it with the elements already present, forms carbon di-oxide and water vapor, and sets free the carbon. This explains the vapor on the tumbler and the soot on the metal. The light is due to the incandescent carbon and the burning gas.

Gas and oil flame burn in exactly

the same way as does a candle. Illuminating gas is a compound of carbon and hydrogen, kerosene oil, of carbon, hydrogen and oxygen. An open light, particularly gas, consumes oxygen from the air and gives off carbon di-oxide. This renders the air unfit for breathing, and is one of the reasons why electric light is preferable in a sick room.

Spontaneous Combustion is the breaking out into flame of substances to which no heat has been applied. It is due to the fact that certain substances have strong affinity for oxygen. For example, a heap of rags wet with turpentine or oil may cause fire; both turpentine and oil have great affinity for oxygen, and persist in uniting with it; the process takes place slowly, but there is heat evolved; this heat cannot escape from a closely packed heap, and so accumulates until it becomes sufficient to ignite the whole mass.

Fire Extinguishers are combinations of chemicals which liberate CO_2 . Poured upon a fire, they deprive it of oxygen and so cause it to die. A com-

mon form of extinguisher has sulphuric acid and carbonate of soda in separate containers; when used, the two are mixed and the reaction produced is as follows: $\text{H}_2\text{SO}_4 + \text{Na}_2\text{CO}_3 = \text{Na}_2\text{SO}_4 + \text{H}_2\text{O} + \text{CO}_2$.

Smothering a fire with a rug or blanket, *i.e.*, preventing the access of oxygen to it, is one of the quickest and most effective ways of extinguishing it. Closing the door tightly if a room is aflame prevents the entrance of oxygen and so slows the fire and hinders its spread.

(The attention of the student is called to the similarity between the breathing of animals and the combustion which takes place in flame.)

Oxidation is similar to combustion, but takes place more slowly. It is *the union of an element, usually a metal, with oxygen*. The rusting of iron is an example; if iron is exposed to air or water, both of which contain oxygen, a slow chemical reaction occurs, and rust, which is iron oxide, (FeO) is formed.

The fermenting of cider to form vinegar, the hardening of paint, the foaming of peroxide in contact with

blood or pus, the change in the color of potassium permanganate solution in contact with certain tissues or with the air, are examples of oxidation. In human nutrition a similar process takes place, food materials giving up their oxygen to the tissues which need it.

Carbon Di-oxide. CO_2 , carbon dioxide, or carbonic acid gas, is one of the important organic compounds. It is an odorless, colorless gas, heavier than air, with a sharp, prickly taste. It is this gas which gives to soda water its effervescence and its pleasing, snappy taste. CO_2 is forced into a tightly closed vessel containing the desired fluid; this is called "charging" it. When the charged liquid is exposed to the air the CO_2 escapes, causing effervescence. The bubbling and sparkling champagne is due to this escape of CO_2 .

In the breathing of animals, oxygen is taken into the system and CO_2 given off. The changes by which this occurs take place largely in the lungs, and to some extent in most of the tissues of the body. The compounds of carbon and hydrogen contained in

the food and assimilated by the system unite with this oxygen, forming CO_2 and H_2O . The water is used in many ways, in the blood, urine, perspiration, digestive fluids, etc., and a small portion is exhaled from the lungs. (Note how you can on a cold day "see your breath" from the freezing of the water vapor contained in it.)

CO_2 is a waste product of the system and is thus gotten rid of. The process of combining the oxygen and the carbon is practically the same as that which takes place in the burning of a candle or lamp; heat is likewise produced. It is to this partly that the bodily heat is due, which is, as we know, about $98\frac{1}{2}$ F. If for any reason the process of combustion and heat production is interfered with, we have a subnormal temperature. If it takes place too actively, there is fever, and material needed in the nutrition of the body is consumed. (The conditions which produce these abnormal chemical changes are very complicated and not well understood.) In some diseases where the temperature rises very high, 105 or over, a part of the red corpuscles

may be killed and the patient may die in consequence.

During the active exercise the blood current flows more rapidly and the exchange of oxygen and carbon dioxide takes place more quickly. This is the reason that exercise warms us, and the lack of it makes us cold. Long, deep breaths answer the same purpose, and furnish one of the best means of keeping warm.

An accumulation of CO_2 in a room or in the system means a lack of free oxygen. A patient in a shut-up room often feels cold, while an out-of-door patient is usually warm. Five per cent of CO_2 causes drowsiness, which is a symptom of poisoning. Ten per cent has caused death. The deaths in the "Black Hole" of Calcutta were due to over-crowding, lack of fresh air, and consequent poisoning by CO_2 .

Fishes and aquatic animals obtain oxygen from the water where it is in solution. Being cold-blooded, they need but a small amount, yet will die without it. Hence the need of furnishing them when in captivity with water

which is fresh, *i.e.*, which contains oxygen.

"Fresh" air is air containing oxygen. "Fresh" water likewise. Water is oxygenated by contact with the air. Thus, dashing, running streams are purer and fresher than still pools. Water may be freed from some impurities by forcing pure air into it.

Plants and CO₂. Plants breathe in an opposite manner from animals, taking carbon di-oxide from the air and exhaling oxygen. The process is somewhat as follows: Plants need a great deal of carbon, and cannot obtain it from the soil; they must therefore get it from the air in the form of CO₂. It enters through the leaves, mostly by the under side, and more actively in sunlight. The carbon is built into the plant in the form of cellulose or woody fibre, starch and sugar. The oxygen which entered in the combination CO₂ is returned to the air as a waste product.

(It was formerly supposed that in darkness plants reversed this process and exhaled CO₂ instead of oxygen, but this has been disproved.)

Thus we see the beautiful and eco-

nomical method by which plants and animals support each other, each using what the other rejects. So in human nutrition, we, by eating, take in what we need for the repair of bone, muscle, brain, etc. We return to the soil our waste products, which contain the material for the nourishment of plants.

LESSON VII.

Composition of Food.

Our food is composed of carbon, hydrogen, nitrogen, oxygen, and small amounts of calcium, phosphorus, sulphur, iron, sodium, chlorine, etc.

We learn in Dietetics to divide foods into four classes—proteids, carbo-hydrates, fats and mineral salts.

Miss Pattee, in her books, gives the following classification of foods:

Nitrogenous	}	Muscle-forming	}	contain S, N, O & H
<i>Proteids</i>		Tissue-building		

(Examples of these are meat and fish, containing the substances called albumin, myosin, fibrin, etc.; eggs, containing legumin; milk, containing casein; and grains, containing gluten.)

Carbo-hydrates

contain CHO work and fuel foods

(Examples of these are sugar in all its forms, and starch found in grains and vegetables.)

Fats

contain CHO work and fuel foods.

Mineral salts form bones, teeth, etc.

Hutchison classifies foods according to the work which they do in the body and the uses to which they are put. The classes are as follows:

Tissue Formers

Proteids

Mineral matters

Water

Work and Heat Producers

Proteids

Albuminoids

Carbo-hydrates

Fats

Mineral matter

Water

Food, to supply the wants of the body, should contain all of these elements in the proper proportions. Children, more even than grown people, should be fed a well-balanced diet. An excess of one class of foods amounts to so much waste material, while a deficiency of any of the needed elements means poor nutrition and weakness of one sort or another.

The proteids and albuminoids are the food materials which contain a considerable quantity of nitrogen along with

the carbon, hydrogen and oxygen. The casein or curd of milk, the myosin of muscle, the gluten of the outer part of the wheat kernel, the legumin of peas and beans, the albumin of the white of egg, and the gelatin of bones are proteid substances and are rich in nitrogen. A more or less large amount of nitrogen is necessary for life and for energy, and a goodly proportion of our food should contain this element. Fruits and vegetables have little or no nitrogen in them and are therefore not sufficient for food; if, however, grains and nuts are added to a fruit and vegetable diet, they supply the nitrogen and give the proper nourishment.

(Urea, the chief waste product thrown off in the urine and the perspiration, also contains nitrogen which has served its purpose in the process of nutrition.)

The *carbo-hydrates* best known to us are the following:

Sugar.....	$C_{12}H_{22}O_{11}$
Starch.....	$C_6H_{10}O_5$
Cellulose.....	$C_{18}H_{30}O_{15}$

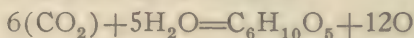
We note that these are composed of the same chemical elements, but in different proportions.

Cellulose is the woody fiber of all plants. Even the tenderest herbs contain a certain quantity of it and it is found more or less extensively in fruits and vegetables. Cotton fiber is almost pure cellulose. It has no great part in the nutrition of the body, but is important for adding bulk to the food and so stimulating the intestines to properly and speedily dispose of waste products. Concentrated foods, or those containing little waste material, tend to produce constipation. Bulky foods, *i.e.*, those containing much cellulose or other waste material, aid greatly in overcoming such a tendency. This is an important reason for eating fruits and vegetables.

Sugar is the only form in which the body can use the elements from these three substances, and both cellulose and starch must in one way or another be changed into it before they can enter the human economy.

Starch is found abundantly in all plants, especially in seeds, grains and

tubers. Green plants manufacture their starch from CO_2 and H_2O , but we know nothing of the exact process. It does not take place in darkness. The reaction is as follows:



The oxygen is returned to the air and the starch is built into the plant tissue.

This starch, in order to be based for the building up of animal tissue, must be changed into sugar of one sort or another. This is often done by the plants themselves, or it may be effected by proper cooking, or it may take place later, during the process of digestion.

Boiling or baking breaks up the starch granules and renders them easily attacked by the digestive fluids. Unbroken starch granules are practically indigestible. This is the chief reason for cooking our food.

The two chief varieties of sugar are *saccharose*, or cane sugar ($\text{C}_2\text{H}_{22}\text{O}_{11}$), and *glucose*, or grape sugar ($\text{C}_6\text{H}_{12}\text{O}_6$), the chief chemical difference being one molecule of water. For some reason unknown to us, this difference

in composition interferes with the assimilation of saccharose by the human economy and it must first be changed into glucose. This transformation is made by the action of ferments such as the ptyalin of saliva, by weak acids as the HCl of the gastric juice, and by heat as in cooking.

(Long boiling of cane sugar converts it into grape sugar, which is considerably less sweet. This is the reason why in canning fruit the sugar should not be put in until late in the process. If added early, it takes more to produce the requisite sweetness.)

Glucose is made in the trades from the cellulose of cotton rags, sawdust, etc., or from starch treated with dilute sulphuric acid. Such sugar is by no means unwholesome, but simply has less sweetening power.

Lactose ($C_{12}H_{22}O_{11}$), the sugar of milk, is of the same composition as cane sugar.

Fructose ($C_6H_{12}O_6$), the same composition as grape sugar, is the sugar of various fruits.

The sourness of unripe fruits is due to the presence of acids, tartaric

(grapes), citric (lemons), malic (apples), oxalic (rhubarb), etc. The heat of the sun causes a gradual decomposition and produces the various forms of fruit sugar.

In growing seed there is starch and a ferment; the warmth and moisture supplied caused the ferment to act and the starch is changed to glucose, ready for the nourishment of the growing plant.

Dextrin is the brown substance of the crust of bread. Its composition is the same as that of starch. It is formed when starch is exposed to a high temperature. It will be remembered that starch is not readily soluble in the digestive juices; dextrin is, however, and it is to this property that its value as a food is due. It may be interesting to note that the crust of bread is its most easily digested part, while the soft inside of the loaf contains starch unchanged and therefore more or less indigestible. The digestibility of toast depends on how much dextrin is present. Toast made too quickly has very little. Zweibach is the form which contains most dextrin.

The *fats and oils* which we use as food are compounds of hydrogen and carbon. Fats are solid substances and are usually obtained from animal sources. Oils are liquid and come from plants and animals.

Both fats and oils are the salts of the so-called *fatty acids*. They are formed by the union of these acids and the base glycerin. The best-known fatty acids are oleic, palmitic and stearic. The most common salts of these acids are olein, found in olive oil; palmitin, found in palm oil and in human fat, and stearin, found in lard. Other fats may be mixtures of two or more of these.

Glycerine is, as we know, a thick, colorless, oily liquid, with a sweet taste. It is made by passing superheated steam under pressure over substances containing fat. It is one of the by-products of soap manufacture. Its formula is $C_3H_5(OH)$.

Cream consists of tiny particles of fat, entangled with the other ingredients of milk. We collect these particles and pack them closely together by the process of churning.

The characteristic flavor of butter is caused by a certain percentage of butyric (a fatty) acid.

Oleomargarine. Beef fat or suet is ground small, cleansed, softened by heat, and separated from the stearin, leaving an oily liquid; this is churned with milk and the product is called oleomargarine or butterine. It is chemically the same as butter, less likely to become rancid, and is—if made from healthy animals—quite wholesome. Some varieties are mixtures of cottonseed oil and lard. Like glucose, these products are objectionable only when sold under a fraudulent name.

The *mineral salts* in our food are compounds of calcium, sulphur, phosphorus, iron, sodium, chlorine, etc. They exist in the husks of grains, in the various fruits and vegetables, in meat, (in minute quantities), and in water. The amount of these needed for proper nutrition is small, but they are absolutely essential. Children whose food lack them often become rickety. In older persons the want of them may produce scurvy.

LESSON VIII.

Digestion. Cooking.

Digestion. The process of digestion and assimilation of foods is very complicated, and much of it is still unknown. The changes which take place are partly mechanical, but mostly chemical. One compound after another is formed and broken up, a new one formed: this, in turn, broken up, etc. The digestive fluids, saliva, gastric juice, pancreatic juice, bile, and intestinal juices are each in turn added to the food and produce a chemical reaction. In health the products formed by these reactions in the alimentary tract furnish the absorbable food substances needed to sustain the tissues. Other products of these reactions are the waste matters which we call excreta.

For proper and complete digestion, proper conditions must exist. If an organ is diseased or acting abnormally in any way, the digestive process is interfered with, as the chemical changes which occur are not the same as in health.

Improper food, improper cooking, or improper eating may be disastrous to digestion. For example, such articles as pickles or Saratoga chips are hardly attacked at all by the digestive juices, nor is the hard outer surface of meat which has been fried in grease. These things are so much waste material, and while they do no harm to a robust digestion might easily become a source of danger to one a little below par. If an excess of cold water be taken with food it not only retards the action of the various juices by lowering the temperature, but dilutes them and renders their work less effective. If food is swallowed without being properly masticated, the saliva (which helps very materially in the digestion of starch) is not present in sufficient quantity to be effective and much of the starchy food becomes waste material.

A large part of the process of digestion is accomplished by means of the ferments.

Ferments are nitrogenous bodies which under certain circumstances have the power of causing chemical

changes in organic substances without themselves suffering any change.

There are two kinds of ferments, *organized* and *unorganized*. There is no essential difference between the action of the two classes.

The *organized ferments* are plants allied to the bacteria. They are very minute.

The *unorganized ferments*, also called *enzymes*, are proteid substances (compounds of C, H, O, and N), which exist in the cells of the salivary glands, of the stomach, the pancreas, and the intestines. They are absolutely necessary to life and nutrition. Even bacteria planted on suitable culture media can use as food only what they dissolve by ferments which they produce for that purpose.

The human body contains a large number of ferments. They act best *at body temperature* and *in a solution*. They lose their activity or die at boiling point.

The following are some of the more important ferments:

Pepsin is one of the constituents of

the gastric juice. It acts only in an acid solution.

Trypsin, *pancreatin*, are found in the pancreatic juice. They act best in a slightly alkaline solution.

Diastase is found in saliva (as *ptyalin*), and to a slight extent in bile, blood, and the pancreas; also in liver and brain substances, kidneys, stomach, intestines, etc. It also occurs in some plants. It has the power of converting starch into sugar.

Rennin occurs in the gastric juice of the calf and the sheep. It coagulates the albumen of milk, forming curd.

Lipase is an interesting example of the action of ferments. It is found in the blood, the liver, and very largely in the pancreas, by which it is secreted. By the help of water, which may be present, it acts upon the fats in the food, decomposing them into glycerin and fatty acids which are absorbed by the lacteals from the intestines. The lipase present in the blood combines with some of the fatty acids and glycerine, making them again into fat, which is stored up for future use.

The *organized ferments* are tiny

plants of the fungus order, the yeast and molds being the best known examples. They, by their growth, break up organic compounds, and it is supposed that somewhere in the process the enzymes or organized ferments are produced.

The organized ferments also cause decay, putrefaction and the various kinds of fermentation.

Decay is a gradual oxidation which takes place in the presence of an acid.

Putrefaction is a fermentation which takes place when there is no acid present. Most of its products are volatile, foul-smelling substances.

Fermentation, in the ordinary sense, is the destruction of sugars by the action of ferments. There must be acid present.

The various kinds of fermentation are named according to their products—alcoholic, acetic acid, lactic acid, mucilaginous, etc. The presence of water is necessary for all these processes.

Certain agents, known to us as antiseptics, prevent the above processes and cause organic matter to “keep,”

that is, they prevent its decomposition.

Alcoholic fermentation.—The making of cider and vinegar furnish excellent illustrations of the varieties of fermentation. The juice of the apple contains sugar (ordinary cane sugar); ferments, usually some variety of yeast getting into it from the air, cause it to “work.” The cane sugar is changed by this action into glucose, and the glucose into alcohol and CO_2 .

After a time, if still left exposed, another organism finds its way into the liquid, attacks the alcohol, and transforms it into acetic acid ($\text{C}_2\text{H}_4\text{O}_2$). This is called “*acetic acid fermentation*” and may be done at will by introducing into the cider the substance which we call “mother of vinegar,” a mass which contains the organisms that produce this particular kind of fermentation.

Lactic acid fermentation changes the sugar of milk (lactose) into lactic acid, which is the substance that makes milk taste sour. Sour milk is not unwholesome, but is, on the contrary, more digestible than sweet milk.

Bread making. Bread which is raised by yeast is fermented.

Yeast is a plant, microscopic in size, which requires for its growth the same conditions that other plants do, warmth, moisture, and suitable soil. We plant it in bread dough, which furnishes these conditions, and a part of the starch of the flour is by the action of the yeast changed into sugar; this sugar ferments, producing alcohol and carbon dioxide. The bubbles of the gas and of the alcohol as it is vaporized by the heat in baking cause the dough to rise and make the bread light.

In *baking powder* cream of tartar (a compound of C H and O) and baking soda (sodium bicarbonate) are mixed in a dry state. When water (or moisture) is added, a chemical reaction takes place and CO_2 is set free. This causes the substance with which it is mixed to rise.

The use of *sour milk* for cooking is upon the same principle. The lactic acid of the milk unites with soda compound, setting free CO_2 .

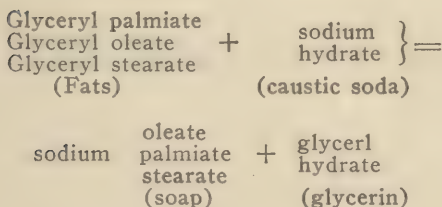
Canning fruit or vegetables is a process of sterilization in which existing

bacteria, ferments or molds are killed and the material sealed so that, because no other organisms can enter it, it will remain in the same condition, indefinitely. We heat the fruit or vegetable to a temperature high enough to kill any existing organisms, and maintain it there for a length of time sufficient to destroy any spores as well. The containers must also be sterilized, either separately or with the fruit in them. They must be tightly sealed in order to prevent the subsequent entrance of bacteria or molds.

LESSON IX.

Cleansing Urinalysis.

Soap. Soaps are the salts formed by the union of the basis NaOH (caustic soda) or KOH (caustic potash) with a fatty acid. The reaction is as follows:



If caustic soda is used, *hard* soap is formed. If caustic potash, *soft* soap.

The following experiment illustrates on a small scale the manufacture of soap:

Mix a small quantity of castor oil with hot water; add a little caustic soda; boil for ten or fifteen minutes. Add a spoonful of common salt and cool. The soap will be formed as a heavy scum on the top.

Action of Soap. Soap dissolves in water, probably uniting with it to form

hydrogen sodium stearate and sodium hydrate. The dirt which we wish to remove by means of soap consists largely of some sort of oil or grease. The sodium hydrate which has been set free attacks this and combines with it to form a new soap. This new soap dissolves in the water and forms the scum with which we are familiar, and which we usually suppose is simply the dirt which has been removed.

Hard and Soft Water. Water, in soaking through the earth to wells or streams from which we get it, on its way dissolves many different substances. Even rain water contains a variety of materials washed out of the air. Most of these substances contained in the water form a clear solution and cannot be detected by the eye. If we boil down a pint of water, however, we nearly always find some solid residue left, this being the mixture of the substances which were held in solution.

The terms, "hard" and "soft" water refer to the nature of the materials contained or dissolved in the solution.

Water is said to be soft when soap produces a ready lather with it; hard when only a sediment or curd is formed. This curd is a lime soap, insoluble in water, which clings to clothing or to the sides of the bowl.

Distilled or perfectly pure water, is soft.

There are two varieties of hard water, one containing chalk (calcium carbonate), and the other gypsum (calcium sulphate). One can readily see that if we wish to soften a hard water, the method used must be in accordance with the matter contained in it. Hard *chalk* water may be made soft by boiling or by adding lime (CaO). Hard *gypsum* (or lime) water, is usually treated with soda (sodium carbonate), or potash or borax.

Cleansing of Metals. When metals tarnish, it is usually due to an oxidation; this obviously takes place more rapidly, as do all chemical changes, in the presence of heat and moisture. Silver tarnish is usually a sulphate, copper tarnish a carbonate, while iron, aluminum, nickel, etc., tarnish are

oxides. These are usually complicated with greasy substances. They may be removed by some substance which dissolves the oxide or other compound, or removes it mechanically. Metal polishes may contain an acid, a solvent of fats (such as gasoline), and a scouring substance (such as whiting).

Urinalysis. The examination of urine belongs largely in the province of the chemist, though it includes microscopy as well. The nurse needs no elaborate knowledge of it, but should be able to make some of the simpler tests, those which determine the presence of substances like albumin, sugar, acetone, etc., the quantity of which may vary from day to day.

Normal urine has a specific gravity of about 1.020, though it may vary from 1.010 to 1.030, depending upon the amount of fluid taken. It should be transparent, of a pale yellow color, though the color may vary considerably without indicating an abnormal condition. The reaction is usually slightly acid.

The normal constituents of urine are

about as follows: Oxygen 72%, carbon 13½%, hydrogen 9% nitrogen 2½%, calcium 1⅓%, phosphorus 1-6%, sulphur, sodium, fluorine, chlorine, potassium, magnesium, iron, silicon and manganese less than one per cent; iodine, arsenic, bromine, aluminium, lead and copper, traces only.

Urine examinations should be made from a twenty-four hour specimen if possible, as isolated specimens may exaggerate conditions.

The following are some of the commoner tests:

Test for albumin. Place a small amount of nitric acid in a test tube. Add to it urine drop by drop. A white ring at the juncture of the two liquids indicates the presence of albumin. A similar test, less reliable, may be made with acetic acid.

Test for sugar (dextrose). Put into a test tube equal amounts of Fehling's solution No. 1 (copper sulphate 35 grams to 500 cc. of water) and No. 2 (173 grams of Rochelle salts and 75 grams potassium hydroxide to 500 cc. of water). Boil. Then add urine, drop by drop. If sugar is present, a

red or yellow precipitate will be formed. If the amount of sugar is very small, it may be necessary to add considerable urine before the precipitate forms.

Test for Acetone. Fill a test tube about one-fourth with urine. Add a few drop of sodium nitro-prussid (5%) and a few drops of acetic acid. If acetone is present, a red color will appear, deepening to purple-red.

Test for diacetic acid. Put some urine into a test tube. Add a solution of ferric chloride, drop by drop, until a precipitate ceases to form. Filter out this precipitate, and add more ferric chloride. If diacetic acid is present, a red color will develop which disappears upon boiling. (If it remains after boiling, it is due to some other substance.)

Test for bile. Place a small amount of nitric acid in a test tube. Add urine drop by drop, so as to form a distinct layer. If there is a play of color, especially green or blue-green, at the juncture of the two liquids, it indicates the presence of bile.

Test for pus. Let the urine stand

until any sediment has settled. Pour off the fluid and use the sediment for testing. Add a strong solution of caustic soda or caustic potash. If pus is present, a viscid mass will be formed. Any mucus present will be curded.

LESSON X.

Chemistry and Materia Medica.

Chemistry is intimately connected with Materia Medica. Both the preparation and administration of drugs demand a considerable knowledge of the nature and action of chemical compounds.

In the handling and care of drugs certain things must be kept in mind. Light causes some drugs, as hydrogen peroxide and silver nitrate, to decompose. If they are not kept in dark bottles or dark closets, changes take place which produce other substances, and so render them unfit for use.

Exposure to the air causes some drugs to evaporate. Camphor gum will disappear entirely if left open. Chloral hydrate crystals evaporate rapidly, even if wrapped in paper. Menthol crystals or those of potassium acetate absorb water from the air (are hygroscopic) and liquefy. Sodium bromide in crystals partly decomposes and partly evaporates unless kept in air-tight vessels. Amyl nitrate evaporates so rapidly that it cannot be

kept at all unless in sealed "pearls," in which way it is usually dispensed. Turpentine almost entirely disappears if left out.

All tinctures are alcoholic solutions, and if not kept cool and tightly corked, evaporate and so become stronger; if these stronger solutions are used an overdose is sure to be given.

Chloroform, if exposed to light and air, decomposes and changes to a dangerous compound. Ether will evaporate through a cork, and cannot be properly kept except in soldered cans. (These are the reasons for buying anaesthetics in small containers. They become unfit for use in about twenty-four hours after being opened.)

Chloride of lime yields up the chlorine gas upon which its disinfecting properties depend if left open; it soon becomes useless if not tightly covered. Potassium permanganate in solution when left open to the air loses its oxygen and is valueless. The change may be observed by its violet color becoming brown. Diuretin powder if not kept in a tight bottle

decomposes, and is thus rendered useless. Any infusion or decoction (infusion of digitalis, etc.), is valueless after a few days, and if not used by the end of a week or two, should be thrown away.

Heat, even in a moderate degree, often causes a slow decomposition resulting in chemical changes and consequent destruction of the original compound. Such changes cause the drug to become an unknown quantity; it may be poisonous, or simply inert, but it is no longer what it was. Vegetable tinctures are especially liable to be decomposed by warmth.

For these reasons, medicine closets should be placed where it is cool, and not too large quantities of drugs supplied. When most drugs become old they should be thrown away. As a general rule, when a tincture or other clear solution becomes muddy or has a deposit at the bottom of the bottle, it should not be used.

Cocaine keeps well in a solid form, but the solutions develop a fungus growth and spoil. Never offer a doctor any solution of cocaine which

is more than twenty-four hours old.

Serums, such as antitoxin, streptolytic serum, etc., must be kept tightly sealed and in a cold place; they are always dated and should be exchanged for fresh if not used before the allotted time is expired.

Mustard is said to "lose its strength" when heated; this is from the evaporation of the oil, which is its active ingredient. Oils, animal (as cod liver oil) or vegetable (as olive), decompose after a time, becoming rancid, and of a different composition from the original substance. If kept cool, this process is delayed. The same thing happens when lanolin or benzoinated lard is used as a basis for ointment. Vaseline, which is a mineral substance, and does not decompose, is more satisfactory for these purposes.

In preparing prescriptions, especially liquid medicines, a knowledge of chemistry is needed, in order to tell whether a certain combination will result in a simple solution or mixture, or whether a precipitate or a new chemical compound will be formed.

Often, when three or four drugs are to be combined, a difference in the method or order of putting them together will spoil the prescription.

In this connection might be mentioned the importance of having bottles, pans, etc., in which specimens of urine or other matter are to be collected, perfectly clean, *i.e.*, free from any particle or other substance. If this be not done, a chemical reaction might easily occur and a specimen respond to a test for a substance which it did not originally contain.

Incompatibility of drugs. Substances are said to be *incompatible* when they cause an undesirable chemical reaction to occur. The experiment with the ammonia and tincture of iron given in Lesson I will illustrate this. If a patient who was taking tincture of iron was given a dose of aromatic ammonia about the same time, both drugs would be ineffective, because the new substance formed by the combination is neither one thing nor the other.

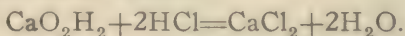
Drugs and foods may also be incompatible. The most familiar example

of this is in the giving of strong acids or alkalies with calomel; it is supposed that in such a combination the mercurous chloride (calomel) is changed to mercuric chloride (corrosive sublimate), a violent poison, and one very readily soluble in the fluids of the body. It is uncertain whether this reaction actually occurs, but it is as well to give the patient the benefit of the doubt. Milk and quinine are incompatibles, forming an unwholesome precipitate, and should not be given close together.

Certain foods are sometimes incompatibles. For example, lemon juice coagulates milk, forming a tough, hard curd, which may or may not cause trouble. Tea given with fish produces an unwholesome tannic acid compound.

Most of the effects produced by drugs are very complicated and difficult to understand. The combination of milk and lime water as given to babies or adults with weak digestion is a case in point. Lime water is calcium hydrate (CaO_2H_2). It is made by adding much boiled water

to unslaked lime (CaO). The reaction is $\text{CaO} + \text{H}_2\text{O} = \text{CaO}_2\text{H}_2$. This CaO_2H_2 when given with milk unites with some of the hydrochloric acid of the gastric juice, makes the acidity of the stomach contents less, and delays the coagulation of the milk. Small curds are formed instead of large ones, and these digest more readily. The reaction is as follows:



(If a bottle of lime water is left open it absorbs CO_2 from the air, forming CaCO_2 , which appears first as a scum and then as a precipitate. CaCO_2 is a form of limestone, and is hardly suitable for a delicate stomach.)

The action of most *cathartics* is mechanical, not chemical. Drugs affect different portions of the digestive tract; cascara, for example, stimulates the muscle of the colon and causes it to force forward its contents. Epsom salts (MgSO_4) forms a solution which is denser than the body fluid and so draws them (by a force called osmosis) into the intestine; the evacuation of intestinal contents is in this case

due to the mechanical effect of an excess of fluid.

Alkaloids. Vegetable alkaloids are probably formed within the living plant cell, as decomposition-products of albumen. In this they are like the ptomaines of meat poisoning, which are the decomposition-products within the living animal cell.

There are seventy-five official alkaloids. The English names end in ine and their Latin ones in ia.

The following is a list of the principal alkaloids used in medicine :

Apomorphine	from	Opium
Atropine	"	Belladonna
Caffeine	"	Coffee
Cinchonine	}	" Cinchona
Cinchonidine		
Cocaine	"	Coca
Codeine	"	Opium
Hyoscine	}	" Hyoscyamus
Hyoscyamine		
Morphine	"	Opium
Nicotine	"	Tobacco
Physostigmine		
Pilocarpine		

Quinine	}	“	Cinchona
Quinidine			
Strychnine		“	Nux Vomica
Veratine		“	Hellebore

Alkaloids are organic bases, and contain carbon, hydrogen, nitrogen, and some of them oxygen. Most of them are solids, but a few are liquid. They are readily soluble in alcohol, but not in water. Their salts, however, are soluble in water, and are therefore used in place of alkaloids themselves, as strychnia sulphate in place of strychnine. The effect is practically the same as that of the alkaloid itself.

WITHDRAWN

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